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Occupational Health Programs Manual – Chapter 9

Radiation Protection for Radiation-Generating Equipment

Approved by: QS/Chief, Safety and Health Division

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NASA - Glenn Research Center
Cleveland, OH 44135

Change Record

Rev.	Effective Date	Expiration Date	GRC25, Change Request #	Description
D	1/17/2011	1/17/2016	225	Added contents to the appendix. Driving requirements here added to 6.1 responsibilities
Change 1	4/11/2014	1/17/2016	n/a	Administrative change to add front cover and change history log to comply with NPR 1400.1, and added "The GRC shall implement requirements of NPR1800.1C and 29CFR1910" in Section 4.0 Policy.
Change 2	9/30/2015	1/17/2016	N/A	Administrative change to remove hyperlinks.
Change 3	11/6/2015	1/17/2017	N/A	Administrative change to correct effective and expiration date.
E	9/16/2016	9/16/2021	16-008	Added RGE category of "Industrial Radiation-Generating Equipment-Linear Accelerator (LINAC) Facility." Inserted section 6.5 to include specific information on controls and requirements for RGE categories. Expanded section on postings/labels.

***Include all information for each revision. Do not remove old revision data. Add new rows to table when space runs out by pressing the tab key in the last row, far right column.*

Contents

Chapter 9—Radiation Protection for Radiation-Generating Equipment

NOTE: The current version of this chapter is maintained and approved by the Safety and Health Division (SHeD). The last revision date of this chapter was September 2016. The current version is located on Glenn intranet with the BMS Library. Approved by: Chief of Safety and Health Division.

1.0 PURPOSE

This chapter describes the policies, procedures, and radiation protection requirements for the procurement and use/operation of radiation-generating equipment (RGE), which includes, but is not limited to, x-ray-producing equipment. RGE produces ionizing radiation without the use of radioactive material (i.e., nuclear sources).

2.0 APPLICABILITY

The provisions of this chapter are applicable to civil servants, support service contractors (SSCs), and construction contractors at the NASA Glenn Research Center's (GRC) Lewis Field and Plum Brook Station.

3.0 BACKGROUND

Radioactive materials (RAM) and RGE are used safely throughout the industrial, medical, and research communities. When not properly controlled, however, sources of ionizing radiation can present a potential hazard to users/operators of such sources, other non-operators in the vicinity, the general public and, for radioactive material use, the environment. Historical and scientific data tell us that very high doses of ionizing radiation received over a short period (acute exposure) and high exposures received over a long period (chronic exposure) present various health hazards to people. The Glenn Radiation Protection Programs establish the policies, procedures, and responsibilities necessary for the safe operation and handling of radioactive materials and RGE.

4.0 POLICY

The GRC Radiation Protection Programs for Radioactive Materials and for Radiation-Generating Equipment are designed to maintain and preserve the health of our employees by eliminating unnecessary exposures and minimizing necessary exposures to ionizing radiation. Exposure to ionizing radiation is to be kept as low as reasonably achievable (ALARA).

All uses of RAM or RGE are approved by the Radiation Safety Officer (RSO) via either the radioactive materials application process, the health and safety plan process, the laboratory standard operating procedure (LSOP) process, the safety permit process, or other use-authorization process. Representatives of the Safety and Health Division (SHeD) periodically assess the ionizing radiation hazards of such activities. The RSO is also responsible for ensuring that an annual audit of the effectiveness of the Radiation Safety Program is conducted. In addition to protecting our workers, the requirements and conditions of Glenn's Radiation Protection Program for Radiation-Generating Equipment comply with applicable regulations of the Occupational Safety and Health Administration (OSHA). The GRC shall follow the requirements of NPR 1800.1 and 29CFR1910 as well as pertinent guidance from the Ohio Department of Health's rules for use of such equipment.

5.0 RESPONSIBILITIES

5.1 Radiation Safety Officer

Ensure activities involving RGE are conducted in accordance with NASA and OSHA requirements. Additional guidance on safety program implementation may stem from industry standards or pertinent state rules. See APPENDIX B for detailed responsibilities.

5.2 Health Physicist or Health Physics Staff

Implement provisions of this chapter and its source policy/regulatory requirements as well as the accepted guidance criteria as directed by the RSO. While the RSO may delegate authority to the HP staff for program implementation, the responsibility to satisfy these program elements remains with the RSO.

5.3 Safety Committee Chairperson

Lead safety permit evaluations and provide guidance to the safety permit requester on how to satisfy permit conditions. In cases involving RGE, the Safety Committee Chairperson will include the RSO as an ad hoc member of their evaluation committee.

5.4 Radiation-Generating Equipment User/Operator

Satisfy training and other requirements of this chapter in addition to working in a safe manner in accordance with established procedures for their particular RGE.

5.5 Radiation-Generating Equipment Site Support Staff

> ***Note:*** *These responsibilities below apply to those staff who support the operation of an RGE facility which generates high dose rates in general areas around the site during machine operation or has the potential to create potentially unsafe conditions after machine operation has ceased. As intended herein, this group would include the electrical, instrumentation, and mechanical technical and engineering staff who support the operation of the LINAC facility.*

Satisfy training and other requirements of this chapter in addition to working in a safe manner in accordance with established procedures for their particular RGE site.

5.6 Supervisors of RGE User/Operator's and RGE Site Support Staff

Ensure RGE user/operator and RGE support staff follow established procedures and meet the requirements specified in this chapter and any applicable safety permits. Also, for Support Service Contractors (SSC), supervisors may be required to maintain medical surveillance and training records.

5.7 Medical Director, Occupational Medicine Services

Provide medical surveillance and post-exposure evaluation, as well as follow-up actions, in accordance with NASA Procedural Requirements (NPR) 1800.1. Records from such examinations and evaluations are to be retained for at least 30 years. Results of examinations are to be discussed with employees as needed. For SSC, such records may alternately be maintained by the employer. Also, as needed, the Medical Director is responsible for meeting agency requirements pertaining to the use of a medical x-ray system, which can include period inspections, maintaining a quality assurance program and correction of system/program deficiencies.

5.8 Human Capital Development Division Chief

Maintain records for employee completion of radiation safety courses and any associated examinations. For SSC, such records may alternately be maintained by the SSC supervision.

5.9 Safety and Health Division Chief

Support the RSO, health physics staff, and safety committee chairpersons in the performance of their duties.

5.10 Support Service Contractor Supervision

If applicable, maintain records for employee completion of radiation safety courses and any associated examinations as well as records of any medical evaluations or examinations triggered because of potential exposure to ionizing radiation.

6.0 REQUIREMENTS

6.1 Training and Qualifications (*NASA NPR1800.1, ODH OAC3701:1-66, ODH OAC3701:1-68, OSHA 29CFR1910.1096*)

> ***Note:*** *The RSO may, in certain situations, specify additional radiation safety training requirements to those indicated below or simply require radiation safety training when none has been identified below. Such situations would typically be identified during the safety permit review process or other use-authorization process and would be handled on a case-by-case basis.*

Note: *The general radiation safety training called out by this section will include both initial and triennial refresher training.*

6.1.1 Analytical Radiation-Generating Equipment - Vacuum Chamber

NASA civil servants and SSCs using analytical RGE where the electron tube is housed within a vacuum chamber are, as a rule, not required to receive radiation safety training. Devices falling under this grouping include, but are not limited to, electron microscopes, x-ray photoelectron spectroscopes (XPS), and Auger microprobes. Other training, on-the-job instruction or qualifications may be required for operators of said equipment to satisfy any local operating criteria along with conditions in applicable safety permits.

6.1.2 Analytical Radiation-Generating Equipment - Cabinet Systems

NASA civil servants and SSCs using analytical RGE where the x-ray emission is contained within a cabinet or where the x-ray emission is not contained shall receive radiation safety training designated by the RSO prior to equipment use and periodically thereafter. Typical cabinet-type systems include laboratory x-ray diffraction (XRD) and x-ray fluorescence (XRF) instruments. Other training, on-the-job instruction or qualifications may also be required for operators of said equipment to satisfy any local operating criteria along with conditions in applicable safety permits.

6.1.3 Analytical Radiation-Generating Equipment - Portable X-ray Fluorescence Instrument

NASA civil servants and SSCs using portable XRF instruments for positive materials identification (PMI) or other metals identification function shall have received either the manufacturer’s training course or comparable onsite device-specific training along with hands-on instruction by a current instrument operator. This instruction on instrument use is a one-time training requirement. Portable XRF instrument users will also be required to periodically receive radiation safety training in addition to satisfying any conditions in applicable safety permits.

6.1.4 Industrial Radiation-Generating Equipment – Irradiation Device in a Vacuum Chamber

NASA civil servants and SSCs using an irradiation device where the electron tube is housed within a vacuum chamber are, as a rule, not required to receive radiation safety training. As discussed here, these vacuum chambers primarily are comprised of metal, although other vacuum units may be appropriate, depending upon the electron tube potential. Typically, the chamber affords tens to hundreds of half-value layers (HVL) of shielding for the radiation source under consideration. Devices falling under this grouping include electron guns (e-guns), electron evaporation and deposition systems, and electron beam welders. Other training, on-the-job instruction or qualifications may also be required for operators of said equipment to satisfy any local operating criteria along with conditions in applicable safety permits.

6.1.5 Industrial Radiation-Generating Equipment.—Industrial Radiography or Irradiation Device in a Cabinet

NASA civil servants and SSCs performing radiography or using an irradiation device in a cabinet-based system shall receive radiation safety training designated by the RSO prior to equipment use and periodically thereafter. This category of RGE includes cabinet x-ray or computed tomography (CT) systems along with cabinet systems whose purpose is to irradiate a target with ionizing radiation. Other training, on-the-job instruction or qualifications may also be required for operators of said equipment to satisfy any local operating criteria along with conditions in applicable safety permits.

6.1.6 Industrial Radiation-Generating Equipment.—Industrial Radiography or Irradiation Device at a Permanent Installation

NASA civil servants and SSCs performing radiography operations in a permanent radiographic installation shall receive radiation safety training designated by the RSO prior to equipment use and periodically thereafter. This category of RGE includes x-ray/computed tomography (CT) systems located in cells, rooms or shielded “walk-in” enclosures. Other training, on-the-job instruction or qualifications may also be required for operators of said equipment to satisfy any local operating criteria along with conditions in applicable safety permits.

6.1.7 Industrial Radiation-Generating Equipment.—Industrial Radiography at a Temporary Job Site (i.e., in the field)

Currently, no NASA civil servants or SSC are involved in performing radiographic testing (RT) at temporary job sites (i.e., in the field). When needed, the radiation safety training requirements for the industrial radiographer and their assistance will be developed by the Center's RSO.

Construction contractors conducting RGE-based, x-ray-type radiography activities at temporary job sites (i.e., in the field) and their assistants must satisfy training and work experience requirements specified by the Ohio Department of Health in Chapter 3701:1-68 of the Ohio Administrative Code or comparable requirements from other states. Records of such training and certification must be made available to GRC's RSO upon request.

6.1.8 Industrial Radiation-Generating Equipment.—Linear Accelerator (LINAC) Facility

> ***Note:*** *As described herein, the LINAC facility and associated operations refer to activities at GRC's Plum Brook Station where LINAC(s) installed in building(s), also known as igloos, 9146, 9147, and/or 9148 are typically operated/controlled from the "B-Control" facility (i.e. building 5411). In certain situations, such as for beam testing and calibration, operation/control of a LINAC may be shifted to a local control station located near the subject igloo. In no instance is anyone ever permitted within the igloo with the LINAC during operation of the particle accelerator.*

NASA civil servants and SSCs responsible for ensuring pre-beam site conditions and controlling production of the LINAC beam, such as the LINAC test conductor, shall receive radiation safety training designated by the RSO prior to performing said functions and periodically thereafter. Other machine- and site-specific training, including on-the-job instruction, will be required for those who are to be qualified as a LINAC facility operator or test conductor.

NASA civil servants and SSCs responsible for supporting the operation of the LINAC facility, such as site technical/engineering staff, shall receive radiation safety training designated by the RSO prior to performing said functions and periodically thereafter.

Depending on the scope of job duties, LINAC Facility staff may be required to satisfy other radiation safety training requirements as specified by the RSO.

6.1.9 Diagnostic Radiation-Generating Equipment.—Medical X-Ray Machine *(if in-service)*

Operators of the medical x-ray machine shall be graduates of an American Medical Association accredited school of radiologic technology. They must be registered with the American Registry of Radiologic Technologists (ARRT) and remain in good standing with this organization by satisfying continuing education requirements of the organization. Radiologic Technologists must also be licensed by the state in which they practice. Additionally, the technicians operating the diagnostic medical x-ray machine shall receive radiation safety training designated by the RSO prior to equipment use and periodically thereafter.

6.1.10 Mailroom X-ray Equipment

Operators of the mailroom x-ray machines shall receive device-specific training from the manufacturer or on-the-job instruction from a qualified machine operator. They shall also receive radiation safety training specified by the RSO prior to machine operation and periodically thereafter.

6.1.11 Other Radiation-Generating Equipment

These individuals shall be trained to operate the RGE involved per the manufacturer's training specifications. The RSO will identify any necessary radiation safety training. Local (i.e. site or facility) criteria for operator qualification may also be applicable.

6.1.12 Ancillary Personnel

These individuals shall be trained to operate the RGE involved per the manufacturer's training specifications. The RSO will identify any necessary radiation safety training.

6.2 Medical Surveillance *(NASA NPR1800.1)*

Radiation medical examinations are conducted in accordance with the requirements set forth in NASA Procedural Requirements (NPR) 1800.1, "NASA Occupational Health Program Procedures." The examinations called out shall be situational, exposure-determined evaluations following potentially high, inadvertent, acute exposures. At a minimum, the exam shall include laboratory blood work along with a medical/occupational history (including exposure). Additional focused physical exam elements shall be based upon the suspected area of the exposure (e.g., a skin exam if high dose was anticipated to the hands).

6.3 Dosimetry (see 8.0APPENDIX C for additional guidelines) *(OSHA 29CFR1910.1096, ODH OAC3701:1-68, NASA NPR1800.1)*

The use of personal dosimetry to estimate external radiation exposure shall be required for certain activities involving RGE. The RSO shall identify when and what type of dosimetry is required. At a minimum, the RSO shall assign personal dosimetry to individuals working with RGE who are likely to receive an annual dose in excess of ten percent of their annual allowable exposure limit. In practice, workers are typically assigned to use dosimetry at much lower exposure levels as described below. For most of the RGE activities at GRC, the anticipated worker exposure is negligible.

> ***Note:*** *Individual circumstances or unusual scenarios may require dosimetry uses that differ from the following guidelines.*

6.3.1 Analytical Radiation-Generating Equipment.—Vacuum Chamber

NASA civil servants and SSCs using analytical RGE where electron tube is housed within a vacuum chamber (e.g., electron microscope, XPS, or microprobes) are not assigned dosimetry.

6.3.2 Analytical Radiation-Generating Equipment.—Cabinet Systems

NASA civil servants and SSCs using analytical RGE where the x-ray emission is contained within a cabinet or enclosure (e.g., lab XRD and XRF systems) are not typically assigned to wear whole body radiation dosimetry. Area dosimetry may be placed near, or, in-line with the operator's position at the discretion of the RSO.

6.3.3 Analytical Radiation-Generating Equipment.—Portable X-ray Fluorescence Instrument

NASA civil servants and SSCs using portable XRF instruments are not assigned dosimetry based upon typical usage of such devices.

6.3.4 Industrial Radiation-Generating Equipment.—Irradiation Device in a Vacuum Chamber

NASA civil servants and SSC using an irradiation device where electron tube is housed within a vacuum chamber (e.g., e-guns, electron evaporation and deposition systems, and electron beam welders) are not assigned radiation dosimetry.

6.3.5 Industrial Radiation-Generating Equipment.—Industrial Radiography or Irradiation Device in a Cabinet

NASA civil servants and SSCs using industrial RGE where the x-ray emission is contained within a cabinet or enclosure (e.g., cabinet X-ray system) are not typically assigned to wear whole body radiation dosimetry. Area dosimetry may be placed near, or, in-line with the operator's position at the discretion of the RSO.

6.3.6 Industrial Radiation-Generating Equipment.—Industrial Radiography or Irradiation Device at a Permanent Installation

NASA civil servants and SSCs performing radiography operations in a permanent radiographic installation (e.g., cell x-ray or CT system) are required to wear personal whole body dosimetry during such work activities.

6.3.7 Industrial Radiation-Generating Equipment.—Industrial Radiography at a Temporary Job Site (i.e., in the field)

Currently, there are no such activities being conducted by NASA civil servant or SSC employees. Construction contractors performing industrial radiography in the field shall satisfy Ohio Department of Health criteria for dose monitoring. Specifically, the radiographer and their assistant(s) are required to wear their personal whole body dosimeters in addition to self-reading dosimeters during field radiography activities.

6.3.8 Industrial Radiation-Generating Equipment.—Linear Accelerator (LINAC) Facility

The need to wear personal dosimetry at and around the LINAC Facility may not be a function of the RGE aspect of the LINAC Facility since the operation of this particle accelerator can result in activation of LINAC components, targets and even building infrastructure. NASA civil servants and SSC employees involved with LINAC Facility operations shall wear personal whole body dosimetry in scenarios described below and also to satisfy any related procedural requirements:

- Location operation/control of LINAC for beam testing or calibration.
- Performance of radiation surveys around LINAC igloo.
- Entry into LINAC igloo immediately following material testing or subsequently when there is known activation of LINAC components or associated infrastructure the results in elevated general-area radiation levels.

6.3.9 Diagnostic Radiation-Generating Equipment.—Medical X-Ray Machine *(if in-service)*

Operators of the medical x-ray machine shall wear personal whole body radiation dosimeters when performing such activities.

6.3.10 Mailroom X-ray Equipment

SSC employees using the mailroom X-ray equipment are not typically assigned to wear whole body radiation dosimetry. Area dosimetry may be placed near, or, in-line with the operator's position at the discretion of the RSO.

6.3.11 Other Radiation-Generating Equipment

The RSO will assess other RGE activities to determine if the use personal or area dosimetry will be required.

6.3.12 Glenn Individual Dose Limits

> ***Note:*** *Dose limits must actually take into consideration doses from sources of radiation that are both outside the body (external) AND inside the body (internal), which, are referred to as Deep Dose Equivalent (DDE) and Committed Effective Dose Equivalent (CEDE), respectively. This DDE is commonly referred to as the "whole body dose" for external radiation dosimetry. The individual dose limits for DDE and CEDE are both 5 rem, as is the overall occupational dose limit, which is referred to as the Total Effective Dose Equivalent (TEDE). As described, the TEDE=DDE+CEDE and none of the three can exceed 5 rem per year. Note that 1 rem is equivalent to 0.01 Sievert (Sv).*

6.3.12.1 Occupational Annual Dose Limits

- Whole body/deep dose equivalent (DDE), total effective dose equivalent (TEDE), or committed effective dose equivalent (CEDE): 5 rem (0.05 Sv)
- Lens of eye (lens dose equivalent (LDE)): 15 rem (0.15 Sv)
- Extremities, skin (shallow dose equivalent (SDE)), specific organs: 50 rem (0.5 Sv)

6.3.12.2 Gestation Period Dose Limit to Unborn Fetus of "Declared Pregnant" Radiation Worker

- Whole body/deep dose equivalent (DDE), total effective dose equivalent (TEDE), or committed effective dose equivalent (CEDE): 0.5 rem (0.005 Sv)

6.3.12.3 Members of the Public Dose Limit

- Annual whole body/deep dose equivalent (DDE), total effective dose equivalent (TEDE), or committed effective dose equivalent (CEDE): 0.1 rem (0.001 Sv)
- Short-term DDE/TEDE/CEDE: 2 mrem (0.02 mSv) in any hour

6.3.13 Dose Investigation

In practice, occupational doses at GRC have historically been well below the stated limits. Should a worker's dose for a recording period appear unexpectedly high or, at a minimum, reach ten percent of the prorated allowable dose for that recording period and that dose is unexpected, the RSO shall initiate an investigation into the cause of the individual's dosimetry results.

6.3.14 Dose Reports

When required by regulations, employees who participate in the dosimetry program shall receive an annual report summarizing their radiation exposure data. Also, at any time, participants can make such a request. In addition, former employees can request dose history results for their period of occupational dose monitoring while at the GRC.

6.4 Inspections and Radiation Surveys of Equipment and Facilities *(NASA NPR1800.1, ODH OAC3701:1-68, FDA 21CFR1020, OSHA 29CFR1910.1096)*

Inspections and radiation surveys of RGE and facilities are used to determine if the equipment is operating properly, if shielding is sufficient, and if associated controls are adequate. If possible, survey conditions will be established that represent a plausible, "worst-case" exposure scenario (i.e., operation at slightly higher-than-typical voltage and/or current, lengthening the exposure period, redirecting the beam path, etc.). Surveys will be conducted by SHeD staff members using appropriate radiation survey meters. Inspections/surveys will be documented using a "GRC Radiological Survey Form" in conjunction with a "Radiation-Generating Equipment Inspection and Survey Form." Location-specific inspection forms may have been created for certain facilities.

The RSO may, in certain situations, determine that an inspection/survey is not necessary based upon the exposure scenario (i.e., photon energy, shielding, etc.). For example, the energy of the x-rays being produced can be so low that it is not possible to measure them using typical radiation surveillance instrumentation. Additionally, the shielding effects afforded by the equipment enclosure along with the relatively small magnitude typical of these sources support the very low hazard potential of such devices. Consequently, as a general rule, no surveys are required to be performed on equipment whose electron tube acceleration voltage is 20 kilovolts (kV) or lower.

There may be other situations where portions of the inspection/survey are waived by the RSO. For example, initial and follow-up radiation surveys were performed at the LINAC facility to characterize dose profiles around the subject building, a.k.a. "igloo," to ensure these levels consistent with dose rates permitted in such areas. Such surveys are typically performed at each operating configuration of the LINAC(s) and these dose profiles may need to be re-assessed to evaluate the impact from changes in machine parameters, beam orientation or facility shielding modifications. If no facility configuration or operations changes have implemented, periodic re-surveys of the LINAC site will not typically be conducted for the following reasons: (1) facility instrumentation closely monitors the operating status/health of the LINAC; (2) area around the LINAC facility is not typically occupied, and (3) surveying these facilities does result in appreciable doses to the surveyors.

The ability to perform surveys on certain equipment may be impacted by the emission parameters of the x-ray tube. For example, the x-ray "shots" taken by a diagnostic x-ray unit in Medical Services are not long enough to be accurately measured by typical radiation surveillance instrumentation. Keeping in mind the purpose of such a perimeter survey, which is the detection of equipment malfunction and shielding degradation and/or compromise and the subsequent potential increase in radiation exposure to the "uncontrolled" population, alternative methods may be utilized to assess the performance of such a system. Since patients are deliberately "exposed" to radiation from this unit, ongoing quality assurance (QA) activities, periodic maintenance and a biennial inspection are employed to assess the health of this system.

6.4.1 Inspection and Survey Schedule

Surveys and inspections of RGE are typically performed upon installation, if the equipment is moved, and on a periodic basis per the schedule below:

6.4.1.1 Biennially

- Analytical Radiation-Generating Equipment—Vacuum Chamber (e.g., electron microscope, XPS, microprobes)
- Industrial Radiation-Generating Equipment—Irradiation Device in a Vacuum Chamber (e.g., e-guns, electron evaporation and deposition systems, and electron beam welders)
- Diagnostic Radiation-Generating Equipment—Medical X-Ray Machine *(if in-service)*

6.4.1.2 Annually

- Analytical Radiation-Generating Equipment—Cabinet Systems (e.g., laboratory XRD and XRF systems)
- Industrial Radiation-Generating Equipment—Industrial Radiography or Irradiation Device in a Cabinet
- Industrial Radiation-Generating Equipment—Industrial Radiography or Irradiation Device at a Permanent Installation (e.g., cell x-ray or CT system)
- Industrial Radiation-Generating Equipment—Linear Accelerator (LINAC) Facility *(inspection only)*
- Mailroom X-ray Equipment

6.4.1.3 Other

- Industrial Radiation-Generating Equipment—Industrial Radiography at a Temporary Job Site (i.e., in the field)

  Field industrial radiography activities are monitored real-time with survey instruments by the radiographer, his assistant(s) and possibly the health physics/SHeD staff to verify boundary radiation levels during radiographic exposures. The radiographer (or their assistant) is also required to survey the x-ray tube once the controller has been turned off in order to verify, in fact, that the tube has been de-energized. No specific "survey" documentation is generated.

- Other Radiation-Generating Equipment

6.4.2 Survey Alternative

In lieu of performing surveys using direct-reading instrumentation, area dosimetry monitoring may also be used by the RSO to assess general radiation levels in areas around X-ray and RGE.

6.5 Equipment Requirements and Other Controls

The following controls and other facility requirements are typical for each type of system described. Based upon the actual system or use scenario, the RSO may waive requirements, allow for alternate controls, or prescribe additional use conditions. When such requirements or controls are not satisfied by the configuration of the RGE device as provided by the manufacturer, those controls/conditions of use may be prescribed by the use-authorization process for the RGE activity.

6.5.1 Analytical Radiation-Generating Equipment.—Vacuum Chamber

Typical instruments falling into this category include electron microscopes, x-ray photoelectron spectroscopes (XPS), and Auger microprobes. Because of the accelerated electrons relatively low energy, the level of shielding afforded by the vacuum chamber walls is typically sufficient to make radiation levels outside the chamber not-measurable using typical instrumentation, and, certainly safe. In addition, analytical RGE-Vacuum Chamber systems usually have vacuum/pressure switches which would inhibit energizing the electron tube without sufficient vacuum in the chamber, thereby ensuring the chamber is sealed prior to the generation of ionizing radiation.

6.5.2 Analytical Radiation-Generating Equipment.—Cabinet Systems

Typical cabinet-type systems include laboratory x-ray diffraction (XRD) and x-ray fluorescence (XRF) instruments. These units will include an interlock safety features to prevent or interrupt x-ray tube operation if or when any access panel/door is opened. Allowable dose rates measured at a distance of 5 centimeters (cm) from the protective cabinet shall not exceed 0.25 mrem/hour. A readily visible warning light, labeled with the words “X-RAY ON” or words or symbols having similar intent, shall be located on or near the source of radiation and its controls and shall be illuminated when the radiation source is energized.

6.5.3 Analytical Radiation-Generating Equipment.—Portable X-ray Fluorescence Instrument

The hand-held XRF instruments used for material identification functions produce an intense, focused X-ray beam when analyzing the target surface area. The NITON units at the Center have two safety features, either of which would effectively mitigate the hazard presented by this direct X-ray beam in most cases. The proximity sensing interlock, which detects the presence of backscattered radiation, will terminate the X-ray emission when the backscatter radiation signal matches that of air. The backscatter sensing interlock is the primary safety feature to prevent emission of an unshielded X-ray beam. Note that the radiation scattered from the test article poses a low hazard to the hand-held XRF operator and no controls are required to mitigate this hazard when the device is used as intended. The second interlock is a proximity button, or, pressure switch which is located adjacent to the X-ray beam aperture. Many sample configurations do not afford the use of the proximity button feature, so this safety interlock is considered optional and is typically disabled. An example of a scenario wherein these backscatter radiation proximity sensor might not mitigate the primary beam hazard would be use of the hand-held XRF while sitting at a table where the operator has the beam directed at a sample on the table’s surface. Considering the location of the operator’s legs, additional shielding or alternative sample/XRF positioning would likely be required. In addition, other use conditions/requirements may be established during the use-authorization process.

6.5.4 Industrial Radiation-Generating Equipment.—Irradiation Device in a Vacuum Chamber

Devices falling under this grouping of RGE include electron guns (e-guns), electron evaporation and deposition systems, and electron beam welders. Similar to electron microscopes and other analytical RGE operating in a vacuum, shielding due to the vacuum chamber walls as well as the operational inhibition of X-ray production on low vacuum (i.e. pressure switch) typically result in a system that is safe to operate with no additional controls being required.

6.5.5 Industrial Radiation-Generating Equipment.—Industrial Radiography or Irradiation Device in a Cabinet

Similar to the cabinet-based analytical RGE systems, these cabinet RGE systems used for X-ray imaging or irradiation of materials shall have interlocked access panels/doors for the cabinet enclosure in addition to external dose rates no greater than 0.25 mrem/hr at a distance of 5 cm from the cabinet’s surfaces. A readily visible warning light, labeled with the words “X-RAY ON” or words or symbols having similar intent, shall be located on or near the source of radiation and its controls and shall be illuminated when the radiation source is energized.

6.5.6 Industrial Radiation-Generating Equipment.—Industrial Radiography or Irradiation Device at a Permanent Installation

Use of an industrial RGE for the purposes of imaging or irradiating materials in a permanent installation would be expected to create a high-radiation area within the room/cell during operation of the X-ray device. Such installations shall be equipped with a failsafe interlock at each entrance used by personnel to access the area, a visible signal/posting that is activated when radiation is produced, and an audible signal that is activated when an attempt is made to enter the area while radiation is being produced.

> *Note: Legacy facility may not have all safety features, but, would still need to be approved by a use-authorization process.*

6.5.7 Industrial Radiation-Generating Equipment.—Industrial Radiography at a Temporary Job Site (i.e., in the field)

These requirements are described in section 6.9.

6.5.8 Industrial Radiation-Generating Equipment.—Linear Accelerator (LINAC) Facility

In addition to being equipped with a failsafe interlock, the access door(s) to the LINAC facility is (are) to be physically locked during machine operation. Warning lights and postings shall communicate the status of the LINAC's production of radiation. An audible and visual warning signal shall be generated within the LINAC facility prior to beam generation and emergency stop buttons, which function to shut down the machine, shall be available in and around the LINAC facility. Radiation detection instrumentation shall monitor radiation levels within the LINAC facility during machine operation.

6.5.9 Diagnostic Radiation-Generating Equipment.—Medical X-Ray Machine *(if in-service)*

The medical X-ray facility shall be equipped with a door interlock to interrupt machine operation if opened. Shielding from the X-ray room's walls, ceiling, floor, door, window(s) shall limit dose rates outside of the room to levels consistent with, or, below those prescribed in current industry standards, such as NCRP Report No. 147 "Structural Shield Design for Medical X-ray Imaging Facilities." Operation of the medical X-ray machine shall comply with applicable federal standards and be consistent with rules specified by the Ohio Department of Health.

6.5.10 Mailroom X-ray Equipment

Typical X-ray (i.e. radiography) equipment used for security screening of mailroom packages involves use of the conveyor system to move the article though the generated radiation field. Operators are not permitted to access/enter this imaging region with any part of their body. These systems will have warning lights to indicate when X-rays are being generated. Doors or panels, which are part of the enclosure and could provide access to the X-ray field, will be interlocked. If the shielding configuration includes lead curtain strips at the entry and exit portals, those strips shall be in good repair. Other safety features included with such systems could include pressure pad interlock for the operator and emergency shut-down buttons.

6.5.11 Other Radiation-Generating Equipment

Equipment and facility requirements for other, non-specified RGE, would likely be consistent with those identified above, but, would need to be reviewed and approved through the applicable use-authorization process. Consultation with the RSO would be recommended in the early stages of associated planning activities.

6.6 Inventory of Radiation-Generating Equipment *(NASA NPR 1800.1)*

The RSO shall maintain a comprehensive inventory of radiation-generating equipment considered to be able to produce hazardous levels of ionizing radiation. The inventory is to be verified annually.

6.7 Review of Radiation Protection Program for Radiation-Generating Equipment *(NASA NPR 1800.1)*

6.7

The RSO shall have a review performed of this program's content and implementation at least once every 12 months. Because of certain program overlap between the ionizing radiation protection programs for RGE and RAM, the annual reviews for these programs may be performed at one time.

6.8 Quality Assurance Inspection of Medical X-Ray Facility *(NASA NPR 1800.1) (if in-service)*

A biennial inspection and performance evaluation shall be conducted for the diagnostic x-ray facility found within Medical Services. The review criteria will be provided by NASA Headquarters in NPR 1800.1 or other official guidance. Typically, this inspection is to be performed by a qualified radiological physicist consultant using metrics established by the Ohio Department of Health (Division of Prevention, Bureau of Radiation Protection, Radiologic Technology Section). The Medical Director and the RSO shall maintain copies of these inspection results.

6.9 Industrial Radiography Using Radiation-Generating Equipment at a Temporary Job Site (i.e., Field Radiography) *(ODH OAC3701:1-68, GRC GLM-QS-1700.1)*

6.9

6.9.1 Portable X-Ray Units

Portable x-ray units are commonly used to perform imaging of equipment/structures/piping (i.e., radiographic testing, or RT) that cannot be moved to an x-ray facility following repairs/modifications or periodic evaluation. Typical target materials here at Glenn include aircraft fuselage, flight hardware or thinner facility piping systems.

Because these field radiography activities are conducted in environments with limited controls, special procedures are needed to minimize potential hazards to the workers involved as well as the general work population. For activities performed by NASA civil servants or SSCs, these procedures would be contained in the safety permit for the activity. Since there are a great variety of potential field locations, these procedures can be thought to describe the safety philosophy and general guidelines for performing radiography shots in the field. Field radiography requirements are established on a case-by-case basis. Typical requirements can include performing the activity during off-hours or on the weekend, evacuating areas, barricading and monitoring the work area, and communicating and coordinating such activities with interested parties. In all cases, the RSO must approve the "plan" and must be notified of the specific time and place of the field radiographic activity.

When such activities are being performed by external RT contractors, their written health and safety plan (HASP) is to describe, in detail, how they will perform their work and manage/control the hazard. The construction safety process and use of the "Health and Safety Plan" is described in Chapter 17 of the Glenn Safety Manual. Contractor's HASPs are approved by SHeD personnel. In cases where the work task involves industrial radiography, the facility RSO will also approve the portions of the HASP which focus on the radiological hazards of the task, or the RSO can approve a separate radiation safety plan.

> ***Note:*** *The RSO's "approval" covers the radiation safety elements of the task; other industrial safety and environmental concerns are to be covered within the HASP (e.g., scaffolding, working aloft, disposal of chemicals) as required by Chapter 17, "Construction Safety," of the Glenn Safety Manual. If the subcontractor is to follow the prime contractor's HASP, then that subcontractor needs to submit an acknowledgement letter (on company letterhead) to the prime contractor indicating that they, the subcontractor, will abide by the prime's HASP. The prime contractor, in turn, will forward this letter to their COTR. Alternatively, the subcontractor may submit their own HASP.*

APPENDIX D of this chapter summarizes requirements for construction contractor performance of field x-ray radiography and it would be the role of the entity needing the testing to inform the RT contractor of these requirements and contact the Center's RSO with any questions. The NASA entity responsible for having the RT contractor on site must also be at the Center during the testing and need to be familiar with the oversight guidelines found in APPENDIX E "Informational Briefing Sheet for Oversight of Radiographic Testing."

6.9.2 Calibration and Maintenance of Portable Radiographic Units

Portable x-ray units used for field industrial radiography operations will be calibrated annually in accordance with manufacturer's guidelines. Records of this calibration and other maintenance performed on these units will be maintained by the radiographer and will be made available to the RSO upon request.

6.10 Use Authorization for RGE (i.e. Safety Permit Process) (*GRC GLM-QS-1700.1*)

The safety permit process, as described in Chapter 1A of the Glenn Safety Manual, is used as the primary method for assessing and addressing potential health and safety hazards associated with activities at GRC. The RSO will assist area safety committees in determining requirements, controls, and conditions for a safety permit involving the use of RGE. Typical permit conditions would include training, posting/labeling, the use of radiation dosimetry, periodic radiation surveys, and written procedures. Depending upon the activity, other use-authorization processes may be implemented.

6.11 Area Postings/Controls and Equipment Labels (*FDA 21CFR1020, OSHA 29CFR1910.1096, ODH OAC3701:1-68, NASA NPR1800.1*)

Restricted and radiation areas shall be marked clearly with signs as designated by the RSO. The signage shall also indicate any special requirements pertaining to the particular area. In addition, labels are required at the point of radiation emission and also on the equipment which controls the production of the x-ray beam. Signs and labels may be available from the RSO.

> *Note: "Radiation" postings/labels typically have a yellow background with magenta (purplish-red) trefoil symbol. Black may also be used for some text. The actual verbiage may vary somewhat depending on the radiation characteristics of the RGE as well as its application, but, the intent is to identify potential sources of hazardous ionizing radiation, areas where hazardous radiation levels*

may exist, and the controls for such equipment, which could be remotely located. Sign layouts may also differ. Images shown herein are typical of such signs/labels.

6.11.1 On or near the housing of the radiation source (Examples provided in Figures 6.1 – 6.3)

"CAUTION – HIGH INTENSITY X-RAY BEAM"

"CAUTION – X-RAYS PRODUCED WHEN ENERGIZED"

"CAUTION – THIS EQUIPMENT PRODUCES IONIZING RADIATION – DO NOT ENTER CONVEYOR DURING X-RAY ACTIVITIES"

"CAUTION – DO NOT INSERT ANY PART OF THE BODY WHEN SYSTEM IS ENERGIZED – X-RAY HAZARD"

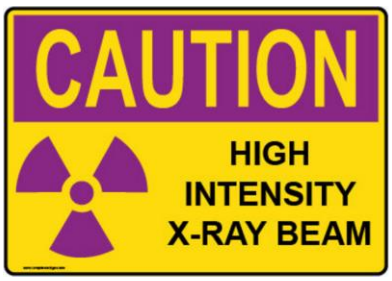

Figure 6.1—X-ray equipment warning label.

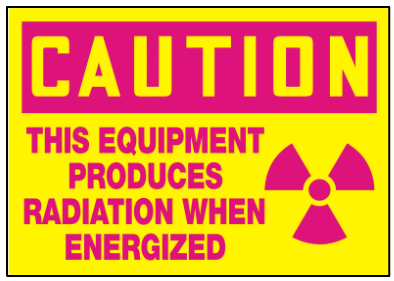

Figure 6.2—X-ray equipment warning label.

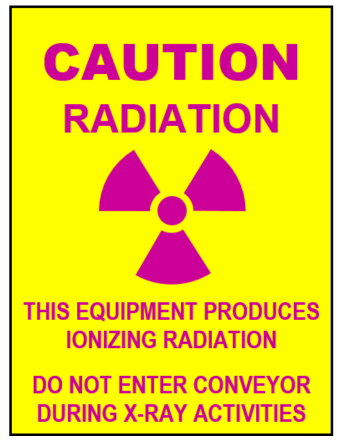

Figure 6.3—LINAC facility warning sign.

6.11.2 On entrances to, or, in areas leading to restricted or radiation areas (Examples provided in Figures 6.4 and 6.5)

"CAUTION – RADITION AREA"

"CAUTION – HIGH RADIATION AREA"

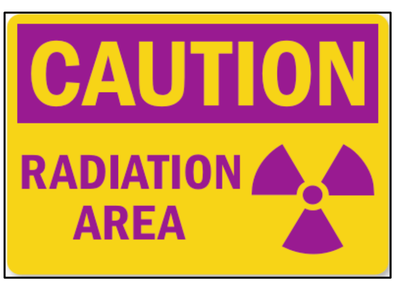

Figure 6.4—Radiation area warning sign.

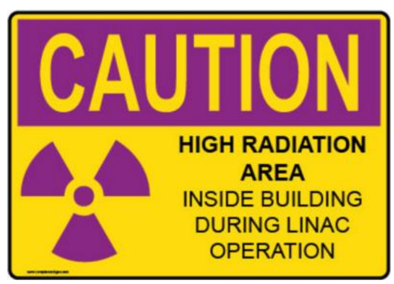

Figure 6.5—LINAC facility warning sign.

6.11.3 On RGE control equipment (Examples provided in Figures 6.6 and 6.7)

"CAUTION – THIS EQUIPMENT CONTROLS THE PRODUCTION OF IONIZING RADIATION"

"CAUTION – THESE CONTROLS ALLOW FOR THE REMOTE OPERATION OF A LINEAR ACCELERATOR WHICH PRODUCES HIGH LEVELS OF IONIZING RADIATION"

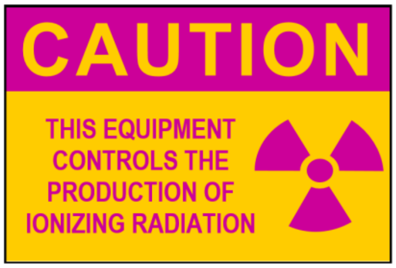

Figure 6.6—Warning label for X-ray control system.

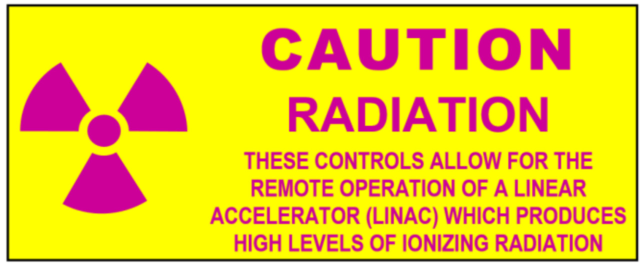

Figure 6.7—Warning label for LINAC control station.

7.0 RECORDS *(MAINTAINED BY THE RSO OR HP UNLESS OTHERWISE NOTED)*

Annual Maintenance & Calibration for Portable Radiographic X-Ray Units.—Maintained by the GRC organization operating said equipment.

Diagnostic X-Ray Facility Inspections & Quality Assurance Surveys.—Maintained by Occupational Medicine Services.

GRC Radiological Survey Form.

Radiation-Generating Equipment Inspection and Survey Form.

Calibration records of survey instrumentation.

Radiation Dosimetry Reports and Records.

Training Records.—Maintained by Human Capital Development Division or Support Service Contractor organization

Medical Exam Records.—Maintained by Occupational Medicine Services or Support Service Contractor organization

8.0 REFERENCES

Document number	Document Name
21 CFR 1020	U.S. Food and Drug Administration, "Performance Standards for Ionizing-Radiation Emitting Products," Sections 1020.30-1020.40
29 CFR 1910.1096	Occupational Safety and Health Administration, "Ionizing Radiation," Section 1910.1096 – Ionizing Radiation
GLM-QS-1700.1	NASA Glenn Safety Manual, Chapter 1A—Safety Permit System
GLM-QS-1700.1	NASA Glenn Safety Manual, Chapter 17—Construction Safety
NPR 1800.1	NASA Procedural Requirement, "NASA Occupational Health Program Procedures"
OAC 3701:1-66	Ohio Administrative Code, "Radiation-Generating Equipment and Quality Assurance Standards"
OAC 3701:1-68	Ohio Administrative Code, "Industrial Radiation-Generating Equipment"

APPENDIX A.—DEFINITIONS AND ACRONYMS

Absorbed Dose- The amount of ionizing radiation energy absorbed in matter, including human tissue. The units of absorbed dose are the rad and the gray (Gy).

Analytical Radiation-Generating Equipment (analytical RGE).—A group of systems or components which produce ionizing radiation as either a primary or a secondary result and is used to determine or alter the properties of materials being measured or analyzed. Analytical RGE includes, but is not limited to, gauging units, electron microscopes, x-ray diffraction, x-ray fluorescence, and spectrometer devices.

American Registry of Radiologic Technologists (AART)

As Low As Reasonably Achievable (ALARA).—Making a reasonable effort to maintain exposures to radiation as far below the dose limits as is practical (1) consistent with the purpose for which the activity is undertaken, (2) taking into account factors such as available technology and the economics of improvements with respect to their benefits, and (3) in relation to the performance of such activities for the public interest.

Committed Dose Equivalent (CDE).—Dose equivalent to an organ during a 50-year period following the intake of radioactive material. The units of CDE are the rem and the sievert (Sv).

Committed Effective Dose Equivalent (CEDE).—A tissue-weighted sum of committed dose equivalent values for organs caused by the intake of radioactive materials. The units of CEDE are the rem and the sievert (Sv).

Computed Tomography (CT).—An imaging procedure that uses multiply x-ray transmission measurements and a computer program to generate tomographic images of a material (or patient).

Continuing Education Unit (CEU)

Diagnostic Radiation-Generating Equipment.—X-ray machines designed for irradiation of any part of the human body or animal for the purpose of diagnosis or visualization.

Diffraction.—An analytical process which reflects/deflects an x-ray beam, which is incident on a target material.

Deep Dose Equivalent (DDE).—The external whole-body exposure dose equivalent at a tissue depth of 1 centimeter (1000 mg/cm^2). The units of deep dose equivalent are the rem and the sievert (Sv).

Dose Equivalent.—The dose quantity used for radiation-protection purposes that takes into account the different effects observed in tissue for different types of radiation giving the same *absorbed dose*. The units of dose equivalent are the rem and the sievert (Sv).

Dosimetry.—Equipment used for measuring and registering accumulated exposure to ionizing radiation. For the purposes of this chapter, these devices include personal monitoring devices such as thermo-luminescent detectors (TLD), optically-stimulated luminescent detectors (OSL), self-reading dosimeters (SRD), or film badges.

Extremity.—For dose purposes, this means hand, elbow, arm below the elbow, foot, knee, or leg below the knee

Fluorescence (Glowing).—An analytical process that uses x-ray beam absorption to cause target materials to emit visible light

Health and Safety Plan (HaSP)

Half-Value Layer (HVL).—The thickness of a material that will reduce the amount of radiation passing through the material to on-half of its initial intensity. This half-value thickness will depend upon the material (density) and the energy of the subject x-rays or gamma rays (particles).

High Radiation Area.—An area, accessible to individuals, in which radiation levels could result in an individual receiving a dose equivalent in excess of 100 mrem in any 1 hr at 30 cm from the radiation source or from any surface that the radiation penetrates.

Industrial Radiation-Generating Equipment (industrial RGE).—This category of RGE means industrial radiography equipment and irradiator devices.

Industrial Radiography Equipment.—A device using ionizing radiation (from either a sealed nuclear source or an x-ray unit) to examine (via real-time imaging, photographic film or other imaging media) the macroscopic structures of material by nondestructive methods.

Ionizing Radiation.—Any radiation (particle or wave) capable of displacing electrons from atoms or molecules, thereby producing ions. Examples: alpha, beta, gamma, x-rays, neutrons, high-speed electrons, protons and other atomic particles.

Irradiation Equipment.—RGE used to alter the chemical, biological, or physical properties of materials or to sterilize materials. Irradiation equipment includes, but is not limited to, electron beam processors, electron beam welders, electron beam coaters, and cabinet irradiators.

Linear Accelerator (LINAC). —A type of particle accelerator that greatly increases the kinetic energy of charged subatomic particles or ions by subjecting the charged particles to a series of oscillating electric potentials along a linear beamline.

Lens Dose Equivalent (LDE).—The external exposure of the lens of the eye and is taken as the dose equivalent at a tissue depth of 0.3 cm (300 mg/cm^2).

NASA Procedural Requirement (NPR)

Occupational Safety and Health Administration (OSHA)

Open Beam.—Analytical RGE configured in a manner so an individual could place any part of their body in the primary beam during operation.

Permanent Radiographic Installation.—A shielded installation or structure designed or intended for radiography an in which radiography is regularly performed.

Quality Assurance (QA)

Rad.—The unit used for *absorbed dose*. 1 Rad = 0.01 Gray (Gy).

Radiation Area.—An area, accessible to individuals, in which radiation levels could result in an individual receiving a dose equivalent in excess of 5 mrem in any 1 hr at 30 cm from the radiation source or from any surface that the radiation penetrates.

Radiation-Generating Equipment (RGE)

Radiation Safety Officer (RSO)

Radioactive Materials (RAM)

Radiographic Testing (RT).—Another phrase for industrial radiography.

Rem.—The unit used for *dose equivalent*. The *dose equivalent* in *rem* is equal to the *absorbed dose* in *rad* multiplied by the quality factor. Also, 1 Rem = 0.01 Sievert (Sv).

Restricted Area.—An area where access is limited for the purpose of protecting individuals against undue risks from exposure to radiation and radioactive materials.

Shallow-dose equivalent (SDE).—The external exposure of the skin of the whole body or the skin of an extremity, is taken as the dose equivalent at a tissue depth of 0.007 cm (7 mg/cm^2).

Safety and Health Division (SHeD)

Support Service Contractor (SSC)

Temporary Job Site.—any location (i.e., in the field) where industrial radiography is performed other that “permanent radiographic installations” specifically designed for such activities.

Therapeutic Radiation-Generating Equipment.—X-ray or electron-producing machines designed and used for external beam radiation therapy.

Total Effective Dose Equivalent (TEDE).—the sum of the deep dose equivalent (for external exposures) and the committed effective dose equivalent (for internal exposures). The units of TEDE are the rem and the sievert (Sv).

X-ray diffraction (XRD)

X-ray fluorescence (XRF)

X-ray photoelectron spectroscope (XPS)

APPENDIX B.—RADIATION SAFETY OFFICER RESPONSIBILITIES

The Radiation Safety Officer (RSO) is appointed by the Center Director to implement the radiation protection programs at Glenn Research Center (GRC). The RSO's responsibilities include the following:

Administer and coordinate the radiation protection programs for all activities involving radioactive materials and ionizing radiation-generating equipment and to ensure that the programs conform to Nuclear Regulatory Commission (NRC) and Occupational Safety and Health Administration (OSHA) regulations as well as NASA policy.

Serve as the RSO for all NRC licenses issued to the GRC and determine compliance with license conditions.

Provide health physics services and consultation to personnel at GRC. Such services shall include the following:

a. Provide, distribute, and maintain personnel radiation monitoring equipment (i.e., dosimetry); assess exposures recorded by such personal monitoring equipment; maintain exposure records.

b. Coordinate the radioactive waste disposal program; provide, collect, store, and dispose of waste containers; monitor effluent; maintain filter systems; maintain waste disposal records.

c. Supervise the performance of sealed source leak test; maintain inventories of radioactive materials and radiation-generating equipment.

Control all licensed radionuclides at GRC as follows:

a. Review and approve all requests for procurement of radioactive material.

b. Assure that sources are properly represented on the Center's materials license.

c. Maintain an inventory of radioactive materials at GRC; conduct physical inventories at least semi-annually to comply with license requirements.

d. Upon notification of receipt of radioactive material shipment, coordinate package survey(s) and open package in approved area; maintain material receipt records.

e. Authorize all transfers of radioactive materials between Center locations.

f. Approve containers and locations for storage of all radioactive materials.

g. Package or inspect packaging for all off-site transfers of radioactive material; survey packages; assure compliance with NRC, Department of Transportation, and International Air Transport Association (IATA) regulations; maintain shipment records.

Conduct or coordinate training programs in radiation safety.

Maintain records related to the radiation protection programs per Section 7.0.

Terminate any activity involving radioactive material or ionizing radiation that is found to be a threat to health or property.

APPENDIX C.—GUIDELINES FOR PERSONAL DOSIMETRY

Obtaining Dosimetry

Individuals needing radiation dosimetry are to contact the Radiation Safety Officer (RSO). After satisfying training requirements and providing needed personal information, the individual will be issued their dosimetry and instructed on its use. New NASA employees who become occupational workers may also be required to provide the RSO with a record of occupational dose from previous employment. Information such as a new worker's accumulated dose for the current calendar year and any past "special exposures" will allow the RSO to appropriately manage their dose received in their inception year and over their career at GRC.

Temporary Need for Dosimetry

Temporary monitoring devices can be issued to transient personnel who may be assigned short-term work in a radiation area. The RSO will evaluate the radiation area and assign monitoring devices as appropriate.

Specification of Dosimetry Type

The need for and type of radiation dosimetry assigned is based upon the characteristics of the ionizing radiation and the type of activity involved. Dosimeters are used to estimate an individual's radiation dose cause by external sources of radiation.

Use of Dosimetry

Whole Body

"Whole body" dosimeters are used to estimate the radiation dose delivered to the head, trunk and thigh area of a worker. This region of the body includes the major organs and blood forming areas that would be more susceptible to chronic radiation exposure effects. This dose is more accurately termed to be the deep dose equivalent (DDE). The "whole body" badge is to be worn in its holder on the front of an individual's body in between their head and waist.

Area

Dosimeters may be used estimate the radiation levels in general areas or in particular locations near sources of ionizing radiation. While not a substitute for the use of personal dosimetry when required, area dosimeters can provide valuable information about the potential radiation hazards.

Self-Reading

Self-reading dosimeters (SRD) are sometimes used to provide a "real time" estimate of an individual's dose to x-rays or gamma rays. SRDs are typically worn in addition to an individual's "whole body badge" when that individual could be involved in an activity involving higher dose rates. The self-reading dosimeter is to be worn similarly to the "whole body" badge. SRDs are to be checked by the user periodically during the exposure event to keep tabs on a worker's accumulated exposure. The dose estimated from an SRD is used for guiding actions during an exposure scenario. The SRD dose does not typically become the individual's official dose of record.

Ring and Extremity Badges

Ring or wrist badges may be specified for activities where a worker's hands come in closer contact to the field of ionizing radiation than their body. Ring badges have higher detection thresholds than whole body badges, and, along those lines, exposure limits for extremities are an order of magnitude greater than whole body limits.

Notify the RSO Immediately

There are certain situations where dosimetry wearers would need to notify the RSO immediately. Users would need to provide a written account detailing the event: who else was involved, when did it occur, what were the radiation characteristics, how long, etc. Situations would include, but are not limited to:

Lost Dosimetry.—if you are unable to find your badge following its use for exposure monitoring.

Damaged Dosimetry.— if your badge's physical integrity was compromised

Unintentionally Irradiated.—if your badge was dropped in an area that subsequently received a high radiation dose causing your badge to be irradiated

Forgot to Wear a Badge.—if you proceeded in performing dosimetry-required activities without being monitored

Involved in a Potential High Exposure.—if you suspect you might have received an acute high dose

In all but the last of these scenarios, the user would be assisting the RSO in finding a way to estimate the individual's true dose for the exposure scenario. Notification in a potential high dose incident is needed to manage the affected individuals' dose(s).

Additional Guidelines for Dosimetry Users

- Wear your dosimeter as specified for the work being performed
- Know where your dosimeter is at all times
- Use only the dosimeter assigned to you
- Use your assigned dosimeter only at GRC's Lewis Field or Plum Brook Station, and only in the areas for which it was assigned
- Never intentionally irradiate your dosimeter to test the efficacy of the radiation protection program
- If you have a medical procedure requiring the use of a radioactive tracer, contact the RSO and do not wear your dosimeter until the tracer has dissipated
- Consult with the RSO regarding any concerns or questions on the use of dosimetry or the dosimetry program

Dosimetry reports are on file with the RSO. Program participants may receive an annual record of their dose and are advised to keep such records for their personal use.

APPENDIX D.—GUIDANCE FOR CONSTRUCTION CONTRACTOR PERFORMANCE OF FIELD X-RAY RADIOGRAPHY

Note: *The Radiation Safety Officer's "approval" on a HASP or separate "radiation safety plan" covers the radiation safety elements of the task; other industrial safety/health and environmental concerns (e.g., scaffolding, working aloft, disposal of chemicals) are to be addressed within the HASP as required by Chapter 17, "Construction Safety," of the Glenn Safety Manual. If the subcontractor is to follow the prime contractor's HASP, then that subcontractor shall submit an acknowledgement letter (on company letterhead) to the prime contractor indicating that they, the subcontractor, shall abide by the prime's HASP. The prime contractor, in turn, shall forward this letter to their COTR. Alternatively, the subcontractor may submit their own HASP.*

- The construction contractor shall follow guidelines specified in the Ohio Department of Health's 3701:1-66-12 "Industrial radiography and irradiation devices utilizing radiation-generating equipment" of the Ohio Administrative Code. Out-of-state contractors, shall follow comparable rules established for their state.
- A copy of the construction contractor's certificate of registration with the Ohio Department of Health shall be included with the health and safety plan (HASP) or otherwise provided to the Radiation Safety Officer (RSO). (Out-of-state contractors shall provide comparable documentation) The contractor shall also provide proof of certification of the radiographer, along with the date of the most recent refresher radiation safety training for the radiographer and their assistant.

Note: *Consideration of the specific area where the radiography is to be performed shall be demonstrated within the proposed plan. Preferably, this familiarity is garnered by the RT company representative working with the hiring contractor, FD representative, RSO and, possibly, the building manager.*

- The HASP for the radiography activity shall demonstrate specific knowledge about the planned shots, how they will be conducted safely, and what coordination issues might exist (i.e., impact on GRC employees or other construction contractors working in the nearby vicinity.) Information shall include a description of the shots being taken: technique, target material and thickness, quantity, spatial orientation, and time. The contactor shall also provide a description of the x-ray tube and controller, including make, model and operating potential to be used for specified activity.
- The HASP shall include a diagram or map showing the location of the 2 mrem/hr isodose line, or, alternatively shall provide a written, detailed description of this demarcation. An exclusion zone based upon a member of the public receiving 2 mrem in any one hour may also be acceptable Any assumptions used in establishing this boundary shall be identified in the HASP or its attachments..
- Areas that need to be evacuated during the radiography shots along with how such areas are to be secured shall identified in the HASP. Coordination with other workers may involve working with the appropriate building manager or the construction manager. Industrial radiography is commonly performed on off-shifts or over the weekend.
- Any other necessary special controls to be implemented during radiography activities shall be described in the HASP.
- The HASP shall list emergency contract numbers for the contractor's RSO, the GRC RSO, and GRC emergency dispatch.
- The NASA entity who will be on site during the radiographic testing shall be familiar with the "Informational Briefing Sheet for Oversight of Radiographic Testing" (APPENDIX E).

APPENDIX E.—INFORMATIONAL BRIEFING SHEET FOR OVERSIGHT OF RADIOGRAPHIC TESTING

Informational Briefing Sheet for Oversight of Radiographic Testing (rev. 08/2016)

Radiographic Testing (RT), or Industrial Radiography, is a non-destructive test method typically used for the macroscopic examination of metal structures or welds. High-energy photons (either gamma-rays or x-rays) are used to examine a target zone with the resulting image being imparted onto either photographic film or a digital image capturing device. In most instances, the industrial radiography will involve the use of gamma rays from a radioactive source such as Iridium-192 or Cobalt-60 (denoted as “GAMMA”). Lower energy photons from x-ray tubes may be needed when performing industrial radiography on light metals and other less-dense materials (denoted as “X-RAY”). Regardless of the photon type (either gamma-rays or x-rays), the action is herein described as an “exposure event” or “exposure shot.”

The NASA organization (civil service or support-service contractor) responsible for bringing in the radiographer shall have a representative onsite for oversight of and coordination with the RT contractor. As the NASA entity coordinating this activity, there are certain basic requirements that you need to be aware of: (if neither GAMMA nor X-RAY are denoted, then the requirement applies to BOTH.)

- Coordinate the arrival of the RT contractor with the Office of Protective Service (OPS), or “Security,” per OPS procedures and processes.
- The RT contractor shall have an approved Radiation Safety Plan or a Health and Safety Plan (HaSP) that covers the scope of the proposed work. (e.g., addendum for the radiography)
- At least two (2) individuals from the RT contractor shall be present; one of these persons is the “radiographer” while the other is the “radiographer’s assistant.”
- In addition to following specific regulations concerning the radiation aspect of the job, the RT contactors shall obey all pertinent industrial safety (i.e., OSHA) requirements, such as those for personal protective equipment, ladder safety, scaffolding, working aloft, confined space, etc. These elements of work safety are to be addressed in the HaSP.
- The “camera,” which contains the radioactive source, shall be under the direct surveillance of the radiographer or their assistant once it has been removed from their truck (GAMMA). Similarly, the x-ray tube/controller, when unlocked, must be under direct surveillance. (X-RAY)
- The RT contactors shall use a whole body dosimeter (e.g., TLD or film badge) AND a direct-reading dosimeter (GAMMA and X-RAY). For radioactive source-based radiography, each RT contractor must ALSO use an alarming doserate meter (GAMMA).
- The RT contractor shall establish the exclusion zone prior to the exposure events. This includes setting up barricades, posting warning signs and verifying that the area is clear of other people. ONLY the RT contractors are permitted within the exclusion zone during exposure shots.
- While performing exposure shots, BOTH of the RT contractors shall be present. At least one shall maintain continuous direct visual surveillance of the operation to ensure the exclusion area is not violated.
- After each exposure event, the RT contractor shall use a radiation survey meter to verify that the source is properly housed in the shielded “camera” (GAMMA) or that the x-ray tube is de-energized (X-RAY)
- The RT contractor’s truck contains a film development laboratory if photographic film is used. Fluids or chemicals shall not be dumped onto GRC property.

If you observe the Industrial Radiographer contractor possibly violate these requirements or if you have concerns about how they are performing their work, you are to approach them with your concerns or questions. If you continue to have such concerns, contact security dispatch at 216.433.2088 for Lewis Field or 419.621.3226 for Plum Brook Station and ask to have the Glenn Radiation Safety Officer (RSO) contacted. You may also contact the RT contractor’s RSO or emergency contact, whose contact information should be in the HaSP or written safety plan for the job.